DEPARTMENT OF COMMERCE

SCIENTIFIC PAPERS

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 401

INFRA-RED TRANSMISSION AND REFRACTION DATA ON STANDARD LENS AND PRISM MATERIAL

BY

W. W. COBLENTZ, Physicist

Bureau of Standards

OCTOBER 27, 1920

PRICE 5 CENTS

Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

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CONTENTS

I. INTRODUCTION

This paper gives exact data on the spectral transparency and, in particular, the refractivity of materials which are useful for prisms and lenses for spectroradiometers.

The data on refractive indices were taken from smooth curves, drawn through values which were collected from various sources and reduced to a common temperature.

It is important, especially in work of the highest precision (such as, for example, the determination of the constant of spectral radiation), to use the most precise instruments and optical data available. It is, therefore, relevant to discuss very briefly some recent designs of optical instruments suitable for spectroradiometry.

The pioneering investigation of the infra-red refractive indices of a substance dates back to 1886, when Langley determined the dispersion of rock salt to about 5μ. In these determinations a spectrometer having an image-forming mirror of long focal length was used. In subsequent determinations of the refractive indices of rock salt and of fluorite, the image-forming mirror of the spectrometer used by Langley had a focal length of 4 to

4.7 m. The apparatus was in a large inclosure which could be maintained at a constant temperature. Langley [19]* was therefore justified in calling attention to the very high precision attainable "owing, if to no other reason, to the far greater size of the apparatus employed, where size is a most important element of accuracy." Other experimenters [20, 23, 24] using his methods, but having spectrometer mirrors of only about one-twelfth the focal length, have attempted to produce similar data which, unfortunately, have been given the widest recognition in tables of physical constants. These published results, especially the older ones, have been very confusing to the writer, who for some years has been confronted with the task of obtaining reliable refractive indices.

The recent measurements on rock salt [26] and on fluorite [28] by Paschen, when corrected for temperature [33, 34], are in agreement with Langley's [19] measurements. The numerical values given in the present paper have been adopted after a careful study of all the data available.

The Spectroradiometer.—For measuring thermal radiation intensities in the ultra-violet part of the spectrum one may use a spectrometer having achromatic lenses of quartz fluorite. However, the scarcity of clear fluorite for large-sized lenses makes such apparatus very expensive.

Pflüger [1] used simple lenses of fluorite 4 cm in diameter (32 cm focal length) and a fluorite prism. An inexpensive spectroradiometer of high light-gathering power was made by Coblentz [2] by using simple plano-convex lenses (6 cm in diameter and 20 cm focal length) and a prism of quartz. Pfund [5] has described similar apparatus, in which the radiometer is kept in focus automatically in different parts of the spectrum.

The apparatus may be designed also as an illuminator for separating the visible from the ultra-violet of, for example, the sun or a quartz-mercury vapor lamp [4].

For spectroradiometric measurements in the visible spectrum and the infra-red to about 0.8μ one can use a spectrometer with visually achromatized lenses of glass. Here, also, it is desirable to use apparatus having a high light-gathering power, such as one obtains with lenses 6 cm in diameter and 20 cm focal length [2, 3, 4].

*These numbered references throughout the text are given in a classified bibliography at the end of this paper.

A common property of all metals is a low reflectivity in the ultra-violet and in the violet-blue part of the visible spectrum [15, 16, 17]. Furthermore, the spectral reflectivity in the short wave lengths is greatly reduced on tarnishing of the metal. Hence, concave mirrors of metals have never been used extensively for spectroradiometric measurements in the visible and in the ultra-violet spectrum.

Because of the lack of achromatism (and the opacity of the material), lenses of glass, quartz, fluorite, etc., achromatized for the visible spectrum have not been used extensively in infra-red spectroradiometric work. Lehmann [46] has described an infra-red spectrograph achromatized for $\lambda = 0.589\mu$ and $\lambda = 1.529\mu$.

A concave mirror is achromatic (also astigmatic), and hence spectrometers with collimating and image-forming mirrors instead of lenses have been used almost exclusively for infra-red spectral radiation intensity measurements. In the infra-red spectrum beyond 2μ most of the metals have a very high reflecting power (90 to 98 per cent), and concave metal mirrors or metal-on-glass mirrors are, therefore, especially useful for infra-red investigations.

Recent designs of spectrometers having collimating and image-forming mirrors are described in papers by Coblentz [6] and by Gorton [9]. Vacuum spectrometers have been described and used by Trowbridge [7] and by McCauley [8].

In order to obtain the spectral energy distribution of an incandescent substance, it is necessary to correct the observations for absorption of radiation by the mirrors and by the prism. The proper formula for eliminating the absorption in a wedge is given by Paschen [29], and by Coblentz [39], who gives also the numerical factors for eliminating the absorption in a wedge of quartz.

It is beyond the scope of this paper to discuss the construction and operation of the instruments (bolometers, thermopiles, etc.) used for measuring the thermal radiation intensities. References are given in the appended bibliography [10] on "Radiometers."

Spectrometer Calibration.—In most spectroradiometric work it is necessary to know the wave lengths at which the thermal radiation intensities are measured. In the visible spectrum it is an easy matter to note the spectrometer settings for the emission lines of some source (for example, the mercury arc or helium gas in a Plücker tube) the wave lengths of whose emission lines are known. Similarly, in the ultra-violet, the emission lines of mer-

cury, cadmium, zinc, etc., may be noted with a fluorescent canary glass screen, or radiometrically with a thermopile [1] or bolometer.

The spectrometer circle may be calibrated for wave lengths in the infra-red spectrum to 1μ, by noting the emission lines [12] of sodium and potassium in a carbon arc; also the emission lines of a quartz mercury vapor lamp and helium in a vacuum tube.

Beyond 2μ, where the emission lines are usually weak (except the strong emission band of carbon dioxide at 4.4μ in the bunsen flame), one can calibrate the prism by noting sharp absorption bands [13,14] such as, for example, the bands of sylvite, *KCl*, illustrated in Fig. 1.

For work requiring great accuracy, the proper method of calibration is by calculating the minimum deviation settings for different wave lengths, using the refractive indices and the angle

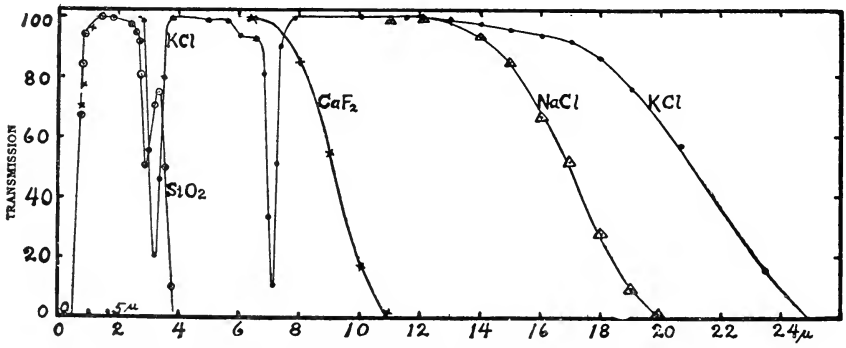

FIG. 1.—*Transmission of quartz (SiO_2); fluorite (CaF_2), rock salt (NaCl), and sylvite (KCl).*

of the prism. For this purpose, the yellow-sodium lines, or, better, the yellow-helium line, $\lambda = 0.5875\mu$, is used as a reference point on the spectrometer circle. The minimum deviation settings for the various infra-red wave lengths are computed from the corresponding refractive indices, and referred to the yellow-helium line as a basis. After this, the bolometer or thermopile is adjusted upon the yellow-helium line, then on rotating the spectrometer through a certain angle, say 2°, the corresponding wave length is, say, 6μ, while a rotation of 4° places the bolometer at about 8.7μ in the spectrum of a 60° fluorite prism (loc. cit.[6], p. 49).

Elimination of Scattered Radiation in Spectral Energy Measurements.—In the design of optical instruments there are opportunities for great improvement in this respect. Take, for example, the image-forming telescope of a spectrometer. The telescope tube

should be large and suitably diaphragmed so that, when the violet end of the spectrum is incident upon the radiometer receiver, the infra-red end of the spectrum can not be reflected from the side of the tube and impinge upon the receiver. Furthermore, the beveled edges of the exit slits of the spectrometer should face outward [18] instead of facing the image-forming lens, as obtains in commercial instruments.

By using suitably constructed optical instruments, the scattered radiation is practically eliminated. What little remains may be obviated by using, before the entrance slit of the spectrometer, a shutter [22,5,18] which is opaque to the region of the spectrum under investigation but which transmits the scattered radiations. In this manner the scattered radiations are incident upon the radiometer all the time and, hence, do not affect the energy measurements. Using a spectrometer which is provided with slits and diaphragms, as just mentioned, it has been found [4] that the scattered radiation was immeasurable, and hence negligible, in comparison with the intensities under investigation.

II. OPTICAL CONSTANTS OF GLASS

In the ultra-violet end of the spectrum ordinary crown glass is transparent to about 0.3μ, while the flint-silicate glasses absorb strongly throughout the blue and violet end of the spectrum.

In the infra-red spectrum, all glasses [38, 40] begin to absorb at about 2μ, and, for a thickness of 1 cm, they are practically opaque to radiations of wave length greater than 3μ. Glasses containing traces of iron impurities have an absorption band at 1μ.

The refractive indices of various glasses have been measured by Rubens [20]. He determined the refractive indices also of water, xylol, benzol, etc. In view of the fact, however, that the refractive indices depend upon the composition of the glass, no refraction data are given in this paper. Practically no infra-red work is being done with glass prisms.

III. OPTICAL CONSTANTS OF CARBON DISULFID

Carbon disulfid is quite transparent in the infra-red. In the region to 3μ Rubens [20] found an absorption of only 5 to 7 per cent, for 1 cm thickness. Beyond 4μ there are a number of very large absorption bands [36].

As illustrated in Fig. 3, carbon disulfid has a very much larger dispersion than quartz, etc., in the region of 0.5 to 2μ and hence is especially adapted for certain fields of spectroradiometry.

The infra-red refractive indices of carbon disulfid were determined by Rubens [20]. Those in the visible and in the ultra-violet were determined by Flatow [32]. Ruben's values of the infra-red refractive indices are given in Table 1.

TABLE 1.—Indices of Refraction of Carbon Disulfid in Air at 15° C (Rubens)

Wave lengths in μ [a]	Refractive index, n	Log n	Wave lengths in μ [a]	Refractive index, n	Log n
0.434	1.6784	0.2248955	0.999	1.6000	0.2041200
.485	1.6550	.2187980	1.073	1.5978	.2035224
.590	1.6307	.2123741	1.164	1.5960	.2030329
.656	1.6217	.2099705	1.270	1.5940	.2024883
.777	1.6104	.2069338	1.396	1.5923	.2020249
.823	1.6077	.2062050	1.552	1.5905	.2015337
.873	1.6049	.2054480	1.745	1.5888	.2010692
.931	1.6025	.2047980	1.998	1.5872	.2006317

[a] Mu=0.001 mm.

IV. OPTICAL CONSTANTS OF QUARTZ

Quartz is one of the most useful materials for prisms. It is extremely transparent to ultra-violet radiations. Pflüger [41] found a transmission of 94 per cent at 0.222μ and 67 per cent at 0.186μ, for a sample of crystalline quartz, 1 cm in thickness. Some samples of amorphous quartz have been found to be more opaque than crystalline quartz, but this may be the result of contamination in melting.

The infra-red transmission of quartz has been determined by various observers. A characteristic absorption band occurs at about 2.95μ. A sample 1 cm in thickness is practically opaque [38] to radiations of wave length greater than 4μ. (See Fig. 1.)

The absorption, reflection, and dispersion constants of quartz are given in a paper by Coblentz [39], who determined the transmission of samples 3 cm in thickness. The paper gives also factors for eliminating the absorption in a quartz prism.

In the short wave lengths the refractive indices of quartz have been determined by Martens [31]. In the infra-red there are important determinations by Rubens [21, 23], Carvallo [35], and Paschen [27]. Carvallo's data extend to 2.2μ and in the region of 1.45 to 1.8μ they are slightly lower (by several units in the fifth decimal place) than three determinations made by Paschen. In this region of the spectrum the data must therefore be considered uncertain with the doubt in favor of Carvallo's data. This uncertainty affects Warburg's [43] determination of the spectral radiation constant by perhaps 0.2 to 0.4 per cent.

The refractive indices (ordinary ray) of quartz at 18° C are given in Table 2. They are taken from a graph of sufficient size to permit reading the data to one or two units in the fifth decimal place. In many cases the values agree exactly with Carvallo's measurements. Paschen's data may be recognized by the fact that his wave lengths are given to the fifth decimal place.

TABLE 2.—Indices of Refraction of Quartz in Air at 18° C (Carvallo, Paschen)

Wave lengths in μ [a]	Refractive index, n	Log n	Wave lengths in μ [a]	Refractive index, n	Log n
0.54609	1.54617	0.1892573	1.3195	1.53076	0.1849071
.58758	.54430	.1887317	1.3685	.53011	.1847226
.58932	.54424	.1887148	1.3958	.52977	.1846162
.61577	.54323	.1884306	1.4219	.52942	.1845268
.66784	.54154	.1879548	1.47330	.52879	.1843478
.6731	.54139	.1879126	1.4792	.52865	.1843081
.6950	.54078	.1877407	1.4972	.52843	.1842427
.70654	.54048	.1876561	1.52961	.52800	.1841234
.72817	.53995	.1875066	1.5414	.52782	.1840722
.7711	.53895	.1872245	1.6087	.52687	.1837921
.8007	.53834	.1870523	1.6146	.52680	.1837822
.8325	.53773	.1868801	1.6815	.52585	.1835118
.84467	.53752	.1868208	1.7487	.52486	.1832300
.8671	.53712	.1867078	1.76796	.52462	.1831616
.9047	.53649	.1865298	1.8487	.52335	.1827997
.9460	.53583	.1863432	1.9457	.52184	.1823690
.9914	.53514	.1861480	2.0531	.52005	.1818579
1.01406	.53486	.1860405	2.062625	.51991	.1818178
1.0417	.53442	.1859443	2.1719	.51799	.1812689
1.08304	.53390	.1857970	2.35728	.51449	.1802664
1.0973	.53366	.1857291	2.3840	.51400	.1801259
1.12882	.53328	.1856214	2.4810	.51200	.1795518
1.1592	.53283	.1854940	2.575	.51100	.1792645
1.17864	.53263	.1854373	2.65194	.50824	.1784704
1.2288	.53192	.1852361	2.79927	.50474	.1774614
1.3070	.53090	.1849468	3.09393	.49703	.1752305

[a] Mu=0.001 mm.

V. OPTICAL CONSTANTS OF FLUORITE

Fluorite is very transparent to radiations of wave lengths extending from 0.2 to 10 μ. (See Fig. 1.) Pflüger [41] found a transmission of 86 per cent at 0.24μ and 70 per cent at 0.186μ, for a sample 1 cm in thickness. Lyman [42] examined fluorites from various sources and of various colors, and found that they are opaque to radiation of wave lengths less than about 0.12μ. Coblentz [38] examined green fluorites with a view of determining their suitability for prisms. He found numerous sharp absorption bands, in the infra-red, which would render such material unsuitable for prisms.

The refractive indices of fluorite have been determined by various observers [21, 23] and repeatedly by Paschen [23, 24, 25, 28]. Applying temperature coefficients of refraction [33, 34] it is found that Paschen's determinations, especially the latest ones [28] which were obtained with an improved spectrometer, coincide with the dispersion curve of fluorite determined, to 3.5μ by Langley [19]. Beyond 4μ the dispersion of fluorite is much larger than at 1.5 to 2μ and there is better agreement among the various determinations of the refac-

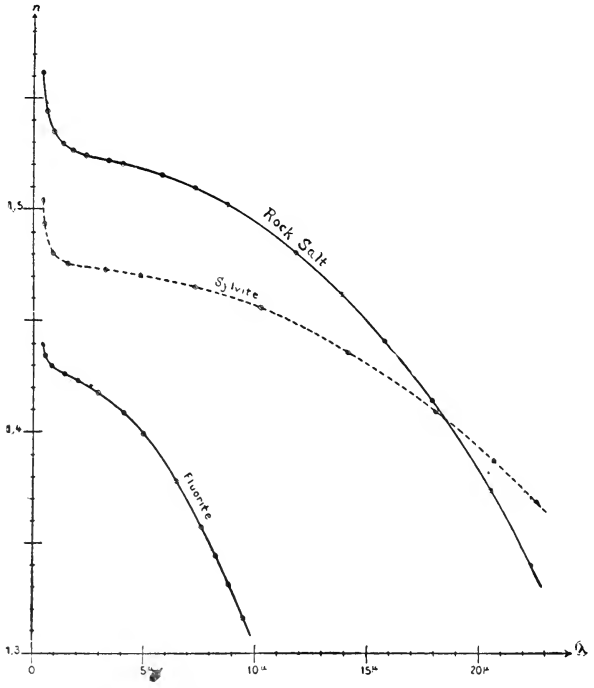

FIG. 2.—*Dispersion curves of prisms (Rubens)*

tive indices. Furthermore, slight deviations have less effect upon spectral radiation measurements.

In Table 3 the refractive indices of fluorite to 3.5μ are taken from the smooth curve published by Langley [19]. In many cases Paschen's original wave lengths are retained. As already mentioned, the corresponding refractive indices, when corrected for temperature of the prism, fall exactly upon Langley's curve of refractive indices.

Beyond 3.5μ the refractive indices are taken from the smooth curve (extended from 3μ) through the various determinations of Paschen [25] and Rubens [20]. All these data are reduced to 20° C.

Langley's data are referred to the "A line" $\lambda = 0.7604\mu$. The most convenient reference point for adjusting a spectroradiometer in the spectrum is the yellow-helium line, $\lambda = 0.58758\mu$. Until recently, when Paschen [28] determined the refractive index of this line, there has been some uncertainty in infra-red spectral radiation measurements [44] requiring the highest accuracy. An error of 5″ (or $n = 3 \times 10^{-5}$) in the determination of this refractive index affects the constant of spectral radiation by 0.3 per cent.

The dispersion curve of fluorite is given in Figs. 2 and 3 (from Rubens').

In the infra-red, the variation of the refractive index of fluorite [34] with temperature decreases slowly with wave lengths. At 1μ the coefficient of variation amounts to about $\Delta n = 0.000012$ and at 6.5μ it amounts to about $\Delta n = 0.000009$, for 1° rise in temperature.

TABLE 3.—Indices of Refraction of Fluorite in Air at 20° C (Langley, Paschen, Rubens)

Wave lengths in μ [a]	Refractive index, n	Log n	Wave lengths in μ [a]	Refractive index, n	Log n
0.48615 Hβ	1.43704	0.1574695	2.5537	0.42080	0.1525329
.58758 He	.43388	.1565120	2.6519	.42018	.1523460
.58932 Na	.43384	.1564995	2.700	.41988	.1522517
.65630 Hα	.43249	.1560916	2.750	.41956	.1521538
.68671	.43200	.1559430	2.800	.41923	.1520528
.72818 He	.43143	.1557601	2.850	.41890	.1519518
.76653 K	.43093	.1556184	2.9466	1.41823	.1517467
.88400	.42980	.1552753	3.0500	1.41750	.1515231
1.0140 Hg	.42884	.1549835	3.0980	1.41714	.1514128
1.08304 He	.42843	.1548589	3.2413	1.41610	.1510939
1.1000	.42834	.1548316	3.4000	1.41487	.1507134
1.1786	.42789	.1546948	3.5359	1.41376	.1503788
1.250	.42752	.1545822	3.8306	1.41119	.1495855
1.3756	.42689	.1543905	4.000	1.40963	.1491051
1.4733	.42642	.1542474	4.1252	1.40847	.1487476
1.5715	.42596	.1541073	4.2500	1.40722	.1483620
1.650	.42558	.1539916	4.4000	1.40568	.1478864
1.7680	.42502	.1538210	4.6000	1.40357	.1472341
1.8400	.42468	.1537173	4.7146	1.40233	.1468502
1.8688 He	.42454	.1536747	4.8000	1.40130	.1465311
1.900	.42439	.1536274	5.000	1.39908	.1458426
1.9153	.42431	.1536046	5.3036	1.39522	.1446427
1.9644	.42407	.1535313	5.8932	1.38712	.1421141
2.0582 He	.42360	.1533880	6.4825	1.37824	.1393312
2.0626	.42357	.1533789	7.0718	1.36805	.1361020
2.1608	.42306	.1532232	7.6612	1.35675	.1324998
2.250	.42258	.1530766	8.2505	1.34440	.1285290
2.3573	.42198	.1528936	8.8398	1.33075	.1240965
2.450	.42143	.1527255	9.4291	1.31605	.1192724

[a] Mu=0.001 mm.

VI. OPTICAL CONSTANTS OF ROCK SALT

Rock salt is uniformly transparent from 0.2μ in the extreme ultra-violet[41] to 12μ in the infra-red[23]. (See Fig. 1.) In the region of 15μ the absorption increases rapidly. A plate of rock salt 1 cm in thickness is completely opaque[22] to radiation of wave lengths greater than 20μ. The refractive indices of rock salt have been determined in the short wave lengths by Martens[30,31] and in the infra-red by Langley[19], by Rubens[21,22] and by Paschen[26]. In the region of 1 to 3μ there is considerable disagreement among the older determinations. However, the recent work of Paschen[26] is in excellent agreement with Langley's measurements which are, without doubt, very accurately determined.

TABLE 4.—Indices of Refraction of Rock Salt in Air at 20° C (Langley, Paschen, Rubens)

Wave lengths in μ [a]	Refractive index, n	Log n	Wave lengths in μ [a]	Refractive index, n	Log n
0.5893	1.54427	0.1887232	3.6288	1.52286	0.1826600
.6400	.54141	.1879182	3.8192	.52238	.1825231
.6874	.53930	.1873233	4.1230	.52156	.1822891
.7604	.53682	.1866230	4.7120	.51979	.1817836
.7858	.53607	.1864110	5.0092	.51883	.1815092
.8839	.53395	.1858112	5.3009	.51790	.1812432
.9033	.53361	.1857149	5.8932	.51593	.1806792
.9724	.53253	.1854090	6.4825	.51347	.1799738
1.0084	.53206	.1852758	6.80	.51200	.1795518
1.0540	.53153	.1851255	7.0718	.51093	.1792443
1.0810	.53123	.1850404	7.22	.51020	.1790345
1.1058	.53098	.1849695	7.59	.50850	.1785453
1.1420	.53063	.1848702	7.6611	.50822	.1784647
1.1786	.53031	.1847794	7.9558	.50665	.1780124
1.2016	.53014	.1847312	8.04	.5064	.1779403
1.2604	.52971	.1846091	8.8398	.50192	.1766468
1.3126	.52937	.1845126	9.00	.50100	.1763807
1.4874	.52845	.1842512	9.50	.49980	.1760333
1.5552	.52815	.1841660	10.0184	.49462	.1745308
1.6368	.52781	.1840693	11.7864	.48171	.1707632
1.6848	.52764	.1840238	12.50	.47568	.1689922
1.7670	.52736	.1839414	12.9650	.47160	.1677898
2.0736	.52649	.1836960	13.50	.4666	.1663117
2.1824	.52621	.1836142	14.1436	.46044	.1644837
2.2464	.52606	.1835716	14.7330	.45427	.1626450
2.3560	.52579	.1834947	15.3223	.44743	.1605976
2.6505	.52512	.1833040	15.9116	.44090	.1586338
2.9466	.52466	.1831730	17.93	.4149	.1507257
3.2736	.52371	.1829024	20.57	.3735	.1378287
3.5359	.52312	.1827341	22.3	.3403	.1272020

[a] Mu=0.001 mm.

The infra-red refractive indices of rock salt, at 20°, are given in Table 4. The first part of the table, to 5μ, consists principally of Langley's (and Paschen's corrected for temperature) measurements as read from the smooth curve (loc. cit.[19], p. 235, Pl. XXIX). Beyond 5μ, to 16μ, the refractive indices are principally Paschen's measurements, corrected for temperature[34]; also some of Rubens's measurements and several interpolated values.

The temperature coefficient of refraction of rock salt,[19,33,34] decreases slowly with wave length; amounting to about $\Delta n = 0.000\,038$ at 1μ and $\Delta n = 0.000\,025$ at 9μ, for 1° rise in temperature.

The general outline of the dispersion curve of rock salt is illustrated in Fig. 2 (from Rubens).

VII. OPTICAL CONSTANTS OF SYLVITE

Of all the substances which are otherwise suitable for prisms, sylvite, *KCl*, is transparent throughout the greatest part of the infra-red spectrum. A plate 1 cm. in thickness transmits [22] radiations to 24μ. (See Fig. 1.) In the region of 5 to 10 μ the dispersion is small. Furthermore, there are sharp absorption[11,13] bands at 3.18 and 7.08 μ. Hence, sylvite is the most useful for investigations in the region of the spectrum extending from 10 to 20 μ.

TABLE 5.—Indices of Refraction of Sylvite in Air at 15° C (Paschen, Trowbridge, Rubens)

Wave lengths in μ [a]	Refractive index, n	Log n	Wave lengths in μ [a]	Refractive index, n	Log n
0.5893	1.49044	0.1733145	8.00	0.46350	0.1653927
.656	.48721	.1723723	8.2505	.46272	.1651642
.7858	.48328	.1712232	8.8398	.46086	.1646086
.845	.48230	.1709361	9.500	.45857	.1639273
.884	.48142	.1706782	10.0184	.45672	.1633760
.9822	.48008	.1702862	10.500	.45475	.1627883
1.003	.47985	.1702177	11.00	.45263	.1621550
1.1786	.47831	.1697655	11.786	.44919	.1611253
1.584	.47650	.1692335	12.50	.44570	.1600782
1.7680	.47595	.1690717	12.965	.44346	.1594048
2.3573	.47475	.1687184	14.144	.43722	.1575232
2.9466	.47388	.1684621	15.00	.4320	.1559430
3.5359	.47305	.1682164	15.912	.42617	.1541713
4.125	.47215	.1679521	16.50	.42230	.1529912
4.7146	.47112	.1676481	17.00	.41885	.1519365
5.3039	.47001	.1673202	17.680	.41403	.1504586
5.50	.46962	.1672050	18.10	.4108	.1494655
5.8932	.46880	.1669627	19.00	.4031	.1470886
6.50	.46750	.1665781	20.00	.3939	.1442316
7.00	.46625	.1662080	20.60	.3882	.1424520
7.661	.46450	.1656894	22.5	.3692	.1364669

[a] Mu=0.001 mm.

In the short wave lengths the refractive indices of sylvite have been determined by Martens [31]. In the infra-red we have various determinations by Rubens [22] (with Nichols and with Trowbridge) by Trowbridge,[45] and by Paschen[26].

The infra-red refractive indices of sylvite are given in Table 5. They are read from the smooth curve (practically Paschen's curve) drawn through the various determinations, all of which are in

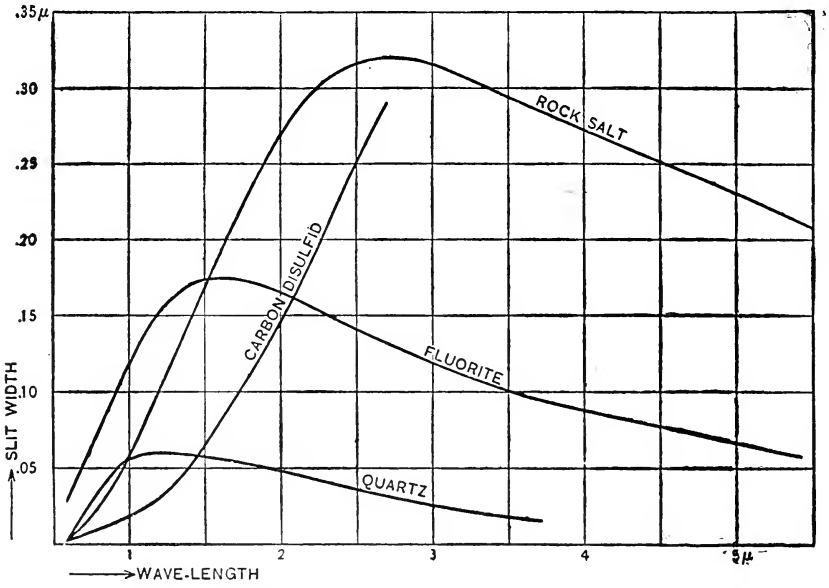

FIG. 3.—*Comparison of dispersion of different substances*

close agreement, except at 9 to 11 μ where the older determinations do not agree very well with Paschen's data.

The temperature coefficient of refraction of sylvite observed by Liebreich[34] decreases from

$\Delta n = 0.000{,}0364$ at $\lambda = 0.589\mu$ to $\Delta n = 0.000{,}031$ at $\lambda = 8.85\mu$.

VIII. SUMMARY: COMPARISON OF DISPERSIVE MATERIALS

In Fig. 3 is given the width that a radiometer receiver, of 4′ of arc, subtends in wave lengths, in different parts of the spectrum produced by prisms of carbon disulfid, quartz, fluorite, and rock salt. These data are required for reducing the spectral energy distribution from the prismatic into the normal spectrum.[6]

From these curves it is evident that, in the region of 0.5 to 1.5 μ, a carbon disulfid prism is the most useful for producing a large dispersion.

The next best prism material is quartz, which is the most useful in the region of the spectrum extending from the visible to 3.8 μ in the infra-red. Beyond this point a quartz prism is too opaque for practical work.

From the standpoint of dispersion and transparency, a fluorite prism is the most useful in the region of 2 to 9 μ. However, the material is difficult to obtain, and the next best substance is rock salt, which permits measurements to 14 μ when using a 60° prism, and to 16 μ when using a 30° prism. By inclosing the spectrometer [14] and by keeping the prism covered when not in use, the faces of a rock-salt prism are easily protected from moisture.

There are but few sylvite prisms in existence, judging from published work, and their usefulness is confined to that part of the spectrum extending from 10 to 20 μ.

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